Discovering the Potential of UV Adhesives

Hightech-Adhesives für schnelle und präzise Fertigungsprozesse

Many adhesives are being used by manufacturers for the assembly and protection of their products. Short cycle time is usually a critical requirement, which can be achieved with UV adhesives and optimally adapted curing technology.

Adhesive bonding has become an indispensable part of many manufacturing processes. The variety of different adhesive and sealing systems is what makes it possible to produce goods and technologies in diverse industries throughout the world. And yet adhesive bonding is only at the beginning of its success story. The reason? No other joining process is so versatile, can be adapted so specifically to customer requirements, and makes a major contribution to a high degree to process reliability and acceleration.

If the topic of fast, precise bonding is being researched, it must always include UV adhesive technology, which has been used for decades in key manufacturing industries such as the automotive, electronics **(Fig. 1)** and medical device. These light-curing adhesives are particularly renowned for their ability to reliably bond a wide variety of substrate combinations in a matter of seconds. Due to the immediate curing of the adhesive, undesired parts movement and adhesive migration is prevented. Immediately after UV-induced curing, the bonded or coated components are ready for handling and further processing.

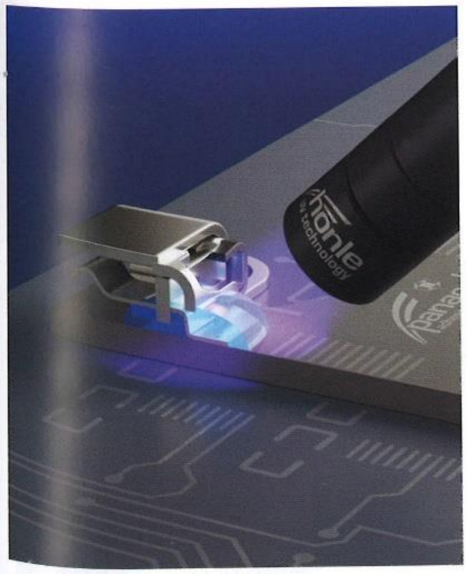

Fig. 1 A connector is bonded and sealed to a PCB with a dual-curing adhesive using a spot lamp. © Panacol

The Photopolymerization Process

UV adhesives contain a variety of chemical compounds. Photoinitiators are essential for the desired rapid curing. In the case of acrylate-based systems, the photoinitiator absorbs UV radiation, free radicals are formed. These radicals trigger the polymerisation reaction, meaning the cross-linking of the vinyl groups with the monomers and oligomers. The polymerisation solidifies the adhesive structure, and the adhesive is cured. UV-curing epoxy adhesives work with a different reaction mechanism: Here, the absorption of UV radiation leads to the decomposition of the photoinitiator and the release of Lewis acids. These react with the epoxy functionalities of monomeric and oligomeric reaction partners, resulting in the formation of polymeric structures and the curing of the adhesive.

UV adhesives have traditionally been cured using UV gas discharge lamps, which emits light in the UVA range from 315nm to 400nm. Today more advanced curing methods are available involving LED technology. LED systems generate monochromatic light energy rather than broad spectrum. Typical wavelength selections include 365, 385, 405 and 460nm. Compared to the classic gas discharge lamps, LED technology has a number of advantages. For example, the use of LED spot systems and arrays does not produce ozone that must be aspirated. In addition, LED radiation does not contain any IR wavelengths, so that the temperature impact on the substrate is reduced. LEDs have a long service life of more than 20,000 hours, which translates into long-term production stability and lower maintenance costs. LED curing systems have neither warm-up or cool-down phases. Cycle times for curing can be set in milliseconds if necessary. Fully automated production lines can be programmed to start-up immediately, with the ability to stop and start again without delay.

The correct procedure for UV bonding

"It all depends on the right choice of UV adhesive". You will hear at the beginning of every bonding project. There is a lot of truth in this statement. However, prior to making the adhesive recommendation, it is important to know the exact requirements of the application, the substrates being bonded, and the intended method for accomplishing the bonding process. The first step is to understand which substrates are being bonded and whether the accessibility for UV light transmission is permitted. Using a transparent substrate, for example, this does not automatically mean that it is also permeable to UV light energy. Many plastics, for example, are UV-blocking, which means that they only transmit wavelengths that lie in the visible light range. This prevents UV radiation from reaching the substrate, which in turn prevents the adhesive from polymerising. Transmission can be checked easily and quickly with the help of a UV measuring device (UV meter or radiometer). Once the transmission of the adhesive is known, a proper adhesive selection can be made to ensure that the adhesive cures as desired. For UV-blocked substrates, adhesives must be selected whose photoinitiators are aligned to visible light, i.e. wavelengths above 405nm. Special dual-curing adhesive formulations are available for shadow zones or undercuts that cannot be reached by light, neither UV nor visible. These dual cure systems are initially cured with UV light. The secondary curing mechanisms include anaerobic, thermal or moisture-initiated curing. With the help of these mechanisms, UV adhesives can be cured in shadowed areas.

UV adhesives are organic materials available as UV acrylates or UV epoxies for bonding applications. Due to their different characteristics and liquid as well as firm mechanical properties, these high-tech adhesives are suitable for micro-dispensing up to large-volume or coating applications. Once it has been established that a UV light curable can be used, it is important to choose the right adhesive for the application. UV light adhesives include both UV acrylates and UV epoxies, and it is important to know the respective advantages of each:

- UV acrylates are based on the previously described radical cross-linking polymerisation. Acrylic systems are ideally suited for bonding plastics, glass and metals. Low-energy plastics can also be bonded reliably using surface treatment such as plasma or corona in conjunction with UV acrylate systems. This versatile technology is used in a wide range of industries, including electronics, automotive and medical. These adhesives are adaptable to low volume manual assembly processes as well as high volume, fully automated production. The advantages of acrylates include very short curing times, capability of layer thicknesses in the millimetre/centimetre range, bonding of dissimilar materials, and ease of dispensing through syringes, valves, or screen printing

- UV epoxies, on the other hand, are based on cationic cross-linking polymerisation. In contrast to the acrylate systems, a cation is formed through the excitation of the photoinitiator with UV light, which leads to the linking of the monomers. This curing is somewhat "slower" than the radical polymerisation, but is still in the range of seconds. Epoxies are known for low water absorption, low shrinkage and very high resistance to temperature, chemicals and mechanical environmental influences. As a result, high-strength bonding and encapsulation can be achieved even where high demands are placed on adhesives at elevated temperatures.

Once the appropriate type of UV adhesive has been identified, the next step is to find the optimal UV or UV LED curing unit. Three factors are essential here:

1. What is the exact process? Is it a laboratory application, a small series, or a fully automated production line? This information provides guidance to help select the type of the curing system as well as the necessary UV light intensity.
2. The chemistry of the adhesive and the transmission of the substrate are used to determine the wavelength of UV radiation under which the adhesive cures most quickly and reliably. These tests can be carried out in advance in the laboratory.
3. The size of the bonding area also plays a role. Is a point source of radiation sufficient? Or do you need to irradiate a larger area? In this case, it is also possible to string together several spot lamps.

Once all these questions have been fully answered and – where necessary – validated by preliminary testing, one can choose from the comprehensive product range of Dr. Hönle AG and individually adapt the devices to the process.

Practical example

Selection of the right UV bonding system for a needle bonding project, **(Fig. 2)**: Needles were to be inserted and bonded into a glass syringe body as part of a fully automated production process. The bonded product was to be subjected to a subsequent fluorescence test to ensure adequate adhesive volume in the bond line. The customer requirements were as follows:

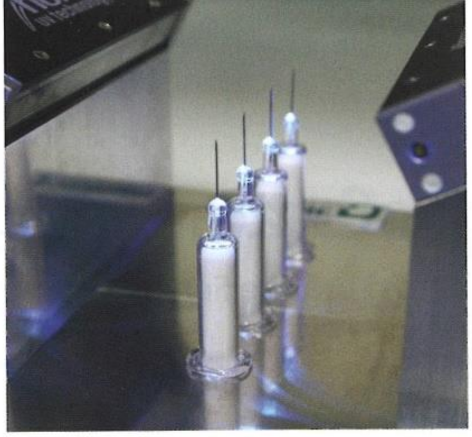

Fig. 2 Needle bonding using an LED line array. © Panacol

- Short cycle times < 1 s
- Adhesive must be biocompatible (medical standards ISO 10993-5 or USP Class VI)
- Sterilisation resistance must be given (steam sterilisation, ETO, Gamma)
- High pull-out force (needle pull-out force of >150 N)
- Fluorescence of the adhesive for quality inspection
- Production under clean room conditions

The approach to adhesive selection first involved familiarizing oneself with the intended process, the production environment, and the most important parameters. These included:

- Analysis of the glass-metal bond for strength and cure speed.
- Transmission values of the specific glass (measurement by UV-meter of > 95% in the wavelength range of 405 nm)

Adhesive selection was done by pre-testing and prior knowledge concerning adhesive suitability for substrate combinations. In this example, a UV acrylate was selected from Panacol's Vitralit adhesives for glass-metal substrates. This adhesive generated high needle pull-out values and possessed high sterilization resistance. A fluorescing version of the tested adhesive was provided to meet the quality inspection requirement for adhesive coverage and volume. Based on the selected parameters such as radiation intensity, irradiation homogeneity and the optimal working distance of the LED UV source to the substrate, the final choice of the LED UV curing system was made. In addition to the bonding surface, the design of the workpiece carrier also played an important role. Needle bonding is about curing individual small, cylinder-shaped bonding surfaces, for which an LED spotlight would normally suffice. However, if the substrates are very close together, an LED line array is usually the better choice – e. g. an LED Powerline LC from Hönle with a wavelength of 405 nm. The suffix LC stands for "Liquid Cooling", i. e. water cooling, a prerequisite for use in clean rooms where active cooling by means of air is not possible.

The quality of the bonded needles is checked after UV curing with the help of another, subsequent LED Powerline LC with a wavelength of 365 nm. This wavelength stimulates the fluorescence integrated in the adhesive and makes the transparent adhesive visible to the eye and camera systems. The quality of the adhesion is immediately checked by irradiating the fluorescence present in the adhesive with UV light to ensure reliable end products and the greatest possible process safety.

Conclusion

UV bonding can revolutionize manufacturing processes in terms of speed and process reliability. For the best results, it is a prerequisite to understand the application and the critical parameters involved in the process. This is essential for the optimization of adhesive and curing unit. Close coordination between adhesive Application Engineering and manufacturer is therefore indispensable. ●

Panacol-Elosol GmbH
Phone: +49 (0) 6171 6202-0
E-Mail: info@panacol.de
https://www.panacol.de

Dr. Hönle AG
Phone: +49 (0) 8105 2083-0
E-Mail: uv@hoenle.de
https://www.hoenle.de

Service

Learn more about bonding options with Panacol:
https://youtu.be/l71959KcY0A
Find your tailor-made UV solution with Dr. Hönle AG: UV LED
https://www.hoenle.de/kontakt#kontaktformular

Authors

Annika Breitschädel
Sales Manager
Dr. Hönle AG
uv@hoenle.de

Eike Leipold
Sales & Marketing Director
Panacol-Elosol GmbH
info@panacol.de